North Carolina State University
Department of Mechanical and Aerospace Engineering

MAE 522 Nonlinear System Analysis and Control
Syllabus
Fall Semester 2023

Schedule: TuTh 11:45am-1pm
Classroom: FWH 2341
Website: wolfware.ncsu.edu

Dr. Fen Wu, Professor
Office: EBIII 3254
Office Hour: M 1-3:30pm, W 9:30-12:00pm
E-mail: fwu@eos.ncsu.edu

COURSE OBJECTIVE:

This course will provide an introduction to fundamental results of modern nonlinear system analysis and control including Lyapunov stability theory, absolute stability, feedback linearization, sliding mode control, backstepping control technique, and other advanced nonlinear control methods.

REQUIRED TEXTBOOK:

Nonlinear Systems (3rd Ed.), by H.K. Khalil, Prentice Hall, 2002.

REFERENCES:

- M. Vidyasagar, *Nonlinear Systems Analysis*, Prentice Hall, 1993.

- S. Sastry, *Nonlinear systems: Analysis, Stability and Control*, Springer, New York, NY, 1999.

- J.J. Slotine and W. Li, *Applied Nonlinear Control*, Prentice-Hall, Englewood Cliff, NJ, 1991.

PREREQUISITE:

A reasonable background in linear multivariable control theory and differential equations.

HOMEWORK POLICY:

Problems are normally assigned every other week and due two weeks later. Since assigned homeworks are an integral part of transferring course content to students, they are to be individual effort. Each new homework problem must begin on a new page. *Late submission of homework assignments will not be accepted without prior approval by the instructor.*

EXAMINATIONS:

There will be one midterm (Oct. 24) during the semester. The final exam will be comprehensive and is scheduled at Dec. 7, 2023. All exams will be open books and open notes. Graded exams will be returned as soon as possible. *There will be no makeup examinations except for extreme circumstances.*

COURSE PROJECT:

You will be given four weeks to work on the course project which emphasizes on one of advanced nonlinear control techniques. The due date of the project will be the last day of instruction (Dec. 5, 2023). The project can be group effort with preferable size of no more than 3 persons for each group. Your results should be provided in a formal report.

GRADING POLICY:

For the course grade assignment, the following weighting basis will be applied:

> Homework 30%
> Midterm 25%
> Project 15%
> Final Exam 30%

The grading scale is:

A_+	> 95	C_+	$73.33 - 76.66$
A	$90 - 95$	C	$70 - 73.33$
A_-	$86.66 - 90$	C_-	$66.66 - 70$
B_+	$83.33 - 86.66$	D_+	$63.33 - 66.66$
B	$80 - 83.33$	D	$60 - 63.33$
B_-	$76.66 - 80$	D_-	$55 - 60$
		F	< 55

TENTATIVE SCHEDULE:

Date	Topics
Aug. 22	Introduction to nonlinear phenomena
	Nonlinear analysis
Aug. 24, 29, 31	Second-order nonlinear systems
Sept. 5	Fundamental properties
Sept. 7, 12, 14, 21	Lyapunov stability theory
Sept. 26, 28	Passivity and $\mathcal{L}$-stability
Oct. 3, 5	Absolute stability
	Nonlinear control methods
Oct. 12, 17, 19	Gain-scheduling control
Oct. 24	Midterm
Oct. 26, 31, Nov. 2	Feedback linearization
Nov. 7, 9	Backstepping method
Nov. 14, 16, 21	Sliding-mode control
Nov. 28, 30	Passivity-based control
Dec. 5	Review
Dec. 7	Final Exam

MISCELLANEOUS:

1. Attendance is expected at all class meetings. The attendance policy is consistent with the Academic Regulation.
   See `www.ncsu.edu/policies/academic_affairs/pols_regs/REG205.00.4.php`

2. It is responsibility of each student to be familiar with the NCSU Code of Student Conduct and in particular with those portions pertaining to academic dishonesty.
   See `www.ncsu.edu/policies/student services/student discipline/POL11.35.1.php`

3. Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantages of available accommodations, students must register with Disability Services for Students.
   See `www.ncsu.edu/policies/student services/courses undergrad/REG02.20.1.php`

4. Online class evaluation will be available for students to complete at end of the semester. Evaluation website is at `classeval.ncsu.edu`